

# Submission in Response to NSF CI 2030 Request for Information

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## Research Domain, discipline, and sub-discipline

Dusty plasmas/astrophysics, planet formation

## Title of Submission

FLUIDS AND PLASMAS ACROSS DISCIPLINES

## Abstract (maximum ~200 words).

Advances in plasma physics (particularly in dusty plasmas) and fluid dynamics have found successful applications in astrophysics and planetary sciences. Although all these disciplines share common themes, the numerical tools used in each discipline can be quite different due to the high level of specialization. Central repositories of codes that can be easily modified by researchers would be greatly beneficial for all these disciplines.

**Question 1** Research Challenge(s) (maximum ~1200 words): Describe current or emerging science or engineering research challenge(s), providing context in terms of recent research activities and standing questions in the field.

The ubiquity of fluids and plasmas in nature demands a high degree of collaboration among scientists. From plasmas produced in laboratories to plasmas permeating galaxy clusters, one can find physical processes that are common even at such disparate length scales. Nevertheless, because of the wide range in values of physical parameters across different systems, it is not always easy to discern common physics in different disciplines. Added to this, computational tools to study spatially and temporally dissimilar fluid and plasma systems have become so specialized that many researchers are unable to invest resources into adapting algorithms to suit their own needs. This may lead to cases of "reinventing the wheel" to address a particular research question, or having to forego tackling a problem altogether.

Recently, at the Lunar and Planetary Science Conference, we presented a poster on numerical simulations of dust growth inside the plasma environment of a protoplanetary disk (the birth site of planets around a young star). A researcher working on dust dynamics in the Martian atmosphere inquired if our algorithms could be applied to his problem (they can). This illustrates that opportunities for

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multidisciplinary collaboration exist for seemingly distinct areas, and the availability of standard, validated algorithms to the plasma science, astrophysics, planetary science and other communities would be hugely beneficial.

Some of the research areas that would benefit from code availability include the formation of planets; solar dynamics; space weather; magnetospheric processes; and interaction of plasmas with solid bodies such as spacecraft and dust grains. Likewise, easy code access would boost the interaction between the fluid dynamics and atmospheric physics communities.

**Question 2** Cyberinfrastructure Needed to Address the Research Challenge(s) (maximum ~1200 words): Describe any limitations or absence of existing cyberinfrastructure, and/or specific technical advancements in cyberinfrastructure (e.g. advanced computing, data infrastructure, software infrastructure, applications, networking, cybersecurity), that must be addressed to accomplish the identified research challenge(s).

An important advancement would be a central repository for data sets and codes that fluid dynamicists and plasma physicists could easily access. An example of such an interdisciplinary code is ImageJ, image processing software developed through grants from the NIH to analyze images from biological systems and medicine ([imagej.nih.gov](http://imagej.nih.gov)). The software was adopted by the astronomy community to analyze images of star fields, with the creation of the AstroImageJ package (<http://www.astro.louisville.edu/software/astroimagej/>).

**Question 3** Other considerations (maximum ~1200 words, optional): Any other relevant aspects, such as organization, process, learning and workforce development, access, and sustainability, that need to be addressed; or any other issues that NSF should consider.

Develop courses aimed at spreading computer literacy among students and researchers, who would be able to learn the latest in computing resources (for example, GPU programming).

## Consent Statement

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